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# SCIENCE

FRIDAY, DECEMBER 10, 1920

## THE DAILY INFLUENCES OF ASTRONOMY<sup>1</sup>

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IN the great struggle through which the principal nations have passed, men and women at home labored intensively to maintain their ideals; countless millions of men fought valiantly and many millions died for the ideals of their nations. Quick results, short cuts to the end in view, the achieving of victory regardless of costs, were the order of the day. Suddenly the problems of war gave way to the problems of peace. The intensive methods of war carried over to an unfortunate degree into the days of peace. Human energy, mobilized in behalf of the nation, applied unselfishly for the good of every person in the nation, for the well-being of all the nations, was diverted in regrettable measure to promoting selfish interests. The moral exaltation of the war period was replaced in too many cases by the selfishness of individuals and organizations; by profiteering—a new word, coined to describe widespread conditions. The struggle in Russia, as the extreme case, is direct action for the sudden attainment of certain results, without due consideration for the rights of others. In all countries there are those who, seeing conditions not to their liking, in commerce, in education, in religion, in many phases of daily life, would cut and slash their way through the good, in order to uproot what, in their sight, is bad. This spirit exists in America, and throughout the world, in various degrees. Disturbances in the body politic may ensue for years or a generation by virtue of these attempted short cuts to results, but radical transformations in the social structure of the great modern nations, to endure, must find

<sup>1</sup> Address on the occasion of the dedication of the Warner and Swasey Observatory, Case School of Applied Science, Cleveland, on October 12, 1920.

the people ready for them. The influences which prepare the way for desirable and enduring reforms are not those applied suddenly, but such as operate day and night, continuously, through long periods of time. The revolutions in Russia, in Mexico, in many parts of Latin America attract our attention, but the really serious misfortunes of those lands lie much deeper, in their bad social, educational, economic conditions, which are operating unfavorably upon their civilizations every day of the year.

We may well inquire what it is that bears a nation onward and upward to greater things. It is unquestionably the spirit of idealism radiating from its various activities. It is the idealism in commercial life: that part of every man's affairs which is conducted with full respect for the rights of others; that part of every man's business which would not, through its publication, injure his good name. It is the idealism of the transportation system, which interchanges commodities to mutual advantage, and acquaints one section of the world with the good things of other sections. It is idealism in banking, in farming, in the honest day's labor at an honest wage. It is idealism in the intellectual life: reverence for the truth, a desire to know the truth, and to live in harmony with the truth in one's surroundings.

A pessimist would to-day, as always, receive short shrift, yet I venture to say the world was perhaps never more urgently in need of the biblical advice, "Prove all things; hold fast that which is good." This expression of great wisdom has never been surpassed as a statement of the principles which govern men of science in their search for the truth.

The chief value of scientific method and accurate knowledge lies not in their worship by the intellectual few, not in their applications to industry, but in their influence upon the daily life of the people. The remarkable advance in civilization within the leading nations in recent centuries has been due to the daily and hourly influence of the scientific spirit, more than to any other element. Those nations which possess it are forging

ahead by leaps and bounds, and those which do not are dropping out of the race. The unscientific nations are threatened with absorption by their more scientific neighbors, not so much because they do not invent or perfect the most powerful cannon, the sturdiest dread-naught, the speediest airplane, or the subtlest submarine, but because the scientific nations are forging ahead of them in the arts of peace, in the modes of thought, in the affairs of daily life. The unscientific nations are without serious influence in the world, not because they are unwarlike—the Turks and essentially all Mohammedans are warlike enough to suit everybody—but because they are lacking in the vision and the efficiency which accompany the scientific spirit.<sup>2</sup>

History affords no more remarkable phenomenon than the retrograde movement in civilization which began with the decline of the Roman power and continued through more than a thousand years. There had once existed a wonderful Greek civilization, but for twelve or fifteen centuries it was so nearly suppressed as to be without serious influence upon the life of the European peoples. Greek literature, one of the world's priceless possessions, not surpassed by the best modern literatures, was as complete two thousand years ago as it is to-day. Yet in the Middle Ages, if we except a few scattered churchmen, it was lost to the European world. A Greek science never existed. Now and then, it is true, a Greek philosopher taught that the earth is round, or that the earth revolves around the sun, or speculated upon the constitution of matter; but excepting the geometry of Euclid and Archimedes, we may say that nothing was proved, and that no serious efforts were made to obtain proofs. There could be no scientific spirit in the Greek nation and Greek civilization so long as the Greek religion lived, and the Greek people and government consulted and were guided by the oracles. If there had been a Greek science equal in merit

<sup>2</sup> This and the following paragraph have been taken, with but few changes, from one of my earlier addresses.—W. W. C.



to modern science, think you that stupidity and superstition could have secured a stranglehold upon Greek civilization and have maintained a thousand years of ignorance and mental degradation? Intellectual life could not prosper in Europe so long as dogma in Italy, only three hundred years ago, in the days of Bruno and Galileo, was able to say, "Animals which move have limbs and muscles; the earth has no limbs or muscles, therefore it does not move;" or as long as dogma in Massachusetts, only 250 years ago, was able to hang by the neck until dead the woman whom it charged with "giving a look toward the great meeting house of Salem, and immediately a demon entered the house and tore down a part of the wainscoting." The morals and the intellect of the world had reached a deplorable state at the epoch of the Borgias. It was the re-birth of science, chiefly of astronomy, as exemplified by the work of Columbus and Copernicus, and secondly the growth of medical science, which gave to the people of Europe the power to dispel gradually the unthinkable conditions of the Middle Ages.

It has been said that we may judge of the degree of civilization of a nation by the provision which the people of the nation have made for the study of astronomy. A review of present-day nations is convincing that the statement represents the approximate truth. It is essentially true even of sections of our own country. In our first years as a nation a few small telescopes were in private hands, here and there; they were used merely for occasional looking at the stars; there were no observatories in the United States—no telescopes suitably mounted and housed for the serious study of the stars. The founding of the third American observatory, at Hudson, Ohio, about 1839, only a year or two after the completion of the second observatory, at Williams College, Massachusetts, was an admirable index to the intellectual outlook of the Western Reserve.<sup>3</sup> The laying of the corner stone of the Cincinnati Observatory in

<sup>3</sup> The northeastern part of Ohio constitutes the "Western Reserve."

1843, a wonderfully ambitious institution for its day, was an event considered by Ex-President John Quincy Adams to be worthy of a hard trip, in the seventy-seventh year of his life, by rail from Massachusetts to Buffalo, by lake steamer to Cleveland, by four days of miserable canal boat to Columbus and thence on to Cincinnati, to deliver the formal address—then called an *oration*. Adams's task was, to quote his words, "To turn this enthusiasm for astronomy at Cincinnati into a permanent and persevering national pursuit, which may extend the bounds of human knowledge, and make the country instrumental in elevating the character and improving the condition of man upon earth."

Our former slave states have to-day only one active observatory, at the University of Virginia, presented by McCormick of Chicago. Barnard and other astronomical enthusiasts, born and grown to manhood in the south, have found their opportunities in the great northern observatories. What is true of astronomy in the south is true, in general, of the other sciences. This unfortunate result is the natural product of the false, unscientific system of labor which, prevailing through many generations, taught that it is undignified for the white man to eat bread by the sweat of his own brow. Financial recovery, following 1865, has accordingly been slow. The future will correct this, for the men of the south are our blood brothers. We should be, and are, sympathetic.

Shall we try to estimate what astronomy, the oldest of the sciences, sometimes called an ideal and unpractical science, has done for mankind?

Here are some of the applications of astronomy to daily life.

1. Observations of the stars with the transit instrument, such as exists in this observatory, are supplying the nations with accurate time. Two astronomers, with modern instrumental equipment, situated on the same north and south line, may observe the stars so accurately, in comparison with the beats of their common clock, that they will agree

within two or three hundredths of a second as to how much that clock is fast or slow.

2. The accurate maps of the continents and islands depend upon the astronomical determinations of the latitudes and longitudes of their salient features.

3. The sailing of ships over long courses, say from the Golden Gate to Sydney, Australia, or from New York to the Cape of Good Hope, depends upon the A B C's of astronomy. Given fair skies the navigator may locate his ship in the middle of the broad ocean within a mile of its true position.

4. In America it is the habit to call upon the astronomers to fix the boundary lines between nations, by observations of the stars; for example, along the 49th parallel of latitude, from Rainy Lake, Minnesota, westward almost to the Pacific Ocean. The uncertainty as to where this imaginary line falls upon the ground is nowhere greater than ten or fifteen feet, and it has not been found necessary by us, nor by our friends in Canada, to maintain military forts along that line.

5. The times of high and low tides, vital to mariners in entering many harbors, are determined by or from the work of the astronomers.

We do not dwell upon these responses to the immediate needs of the world, for they are unimportant in comparison with the contributions of the pure knowledge side of astronomy to progressive civilization.

Let us think of the earth as eternally shrouded in thick clouds, so that terrestrial dwellers could never see the sun, the moon, the comets, the stars, and the nebulae, but not so thick that the sun's energy would fail to penetrate to the soil and grow the crops. Under these conditions we might know the earth's surface strata to the depth of a mile or two. We might know the mountains and the atmosphere to a height of four or five miles. We might acquire a knowledge of the oceans, but we should be creatures of exceedingly narrow limits. Our vision, our life would be confined to a stratum of earth and air only four or five miles thick. It would be as if the human race went about its work of raising corn for food and cotton for raiment,

always looking down, never looking up, knowing nothing of the universe except an insignificantly thin stratum of the little earth. This picture is only a moderately unfair view of life as it existed on our planet four hundred years ago, before the days of the telescope, the spectroscope and the photographic plate, before the days of freedom of speech and thought, which came with the scientific spirit. The earth is for us no longer flat, supported on the back of a great turtle, which rests upon nothing. It is round, and every civilized person knows that it is. Exists there an intelligent man in the world whose thoughts, every day and many times a day, are not unconsciously adapted to this fact? This knowledge is a chief inheritance of the new generations. It is fundamental in our civilization. People know that the sun will rise in the morning and set in the evening, and why. A round earth, rotating upon its axis in a dependable way and revolving around the sun in exact obedience to law, are truths incomparably more sublime than the fiction of the flat earth which was pictured hazily in men's minds during pre-Copernican days. Who can estimate the value of this knowledge to the human race? It can not be expressed with the few figures which suffice for the total of present-day financial transactions.

The stars are not lanterns hung out in the sky by angels at night, but something inconceivably grander; they are suns, hundreds of millions of suns, on the average comparable in size and brightness to our sun. Is not this ascertained fact of nature a most ennobling one to aspiring souls? Do not these facts suggest and develop becoming modesty in the minds of those who would know the truth and pattern their lives in accordance with it?

The following conversation occurred one Saturday evening in the month of June, 1912, at the eyepiece of the great telescope which Mr. Warner and Mr. Swasey constructed and erected for the Lick Observatory: I mention the time, June, 1912, because it is of the essence of the story.



Said the astronomer to the party of visitors: "The object which you will see through the great telescope this evening is the star cluster in Hercules, the finest cluster in the northern sky. Without the telescope, by naked eye, this cluster may be seen if the observer knows exactly where to look and has first-class eyes, but he will see it as apparently a single star on the limit of vision, so faint that many eyes will not see it at all. The telescope separates the cluster into a multitude of stars. If you had the time to count them, they would number fully six thousand, closely grouped in the center of the cluster, but thinning out as you approach the edges. This one object, then, which to the naked eye seems to be a single star on the limit of vision, consists of at least as many stars as the eye alone is able to see in the sky as a whole, northern and southern skies, summer and winter skies combined, and we do not doubt that long photographic exposures on the cluster, with a large reflecting telescope, would record many more than six thousand. Each of these stars is a sun and probably every one of those which you will see is larger than our sun, for we are observing merely the brightest members of the system. We do not know whether these suns have planets revolving around them or not, as the cluster is entirely too far away for us to see such planets, but planets probably exist there in great numbers; possibly there are planets revolving around all of those stars; possibly and probably there are moons revolving around the planets; and finally, there may be life, vegetable, animal, intelligent life upon those planets."

One of the visitors upon descending from the observing chair, much interested, questioned the astronomer: "Did you say those stars are all suns?" "Yes, sir." "Did you say that those stars are really larger than our sun, on the average?" "Yes, sir." "Can you give me an idea how large our sun is?" "Well, if it were a hollow shell, of its present size, you could pour more than a million earths into it, and there would still be much unoccupied space between the earth balls." "You say, there are possibly or probably

planets revolving around many of the cluster stars?" "Yes, sir." "And many of those planets may be inhabited?" "Yes, sir." "Well then, I think it does not matter very much whether Roosevelt or Taft is nominated next week at the Chicago Convention."

Of course the visitor's interest in the outcome at Chicago was just as keen as ever, but he had evidently received a valuable lesson concerning man's place in nature.

The wonders of our sun are many and most remarkable, and are but little known. I have referred to its enormous size. The quantity of heat which the sun is radiating into surrounding space, to the earth, to Mars, and to all other objects which intercept its rays, is stupendous and not to be comprehended by the astronomer or the man of affairs. It is, and has been, the source of all the energy upon which we draw, save only a negligible residual. A great quantity of heat is indeed stored up in the interior of the earth, but it reaches the earth's surface in such minute quantities that in all practical details of life, save to those who labor in deep mines, or live near volcanoes, or are interested in hot springs, this source of energy may be neglected. If this statement should be difficult to accept, let your thoughts travel to the south pole of our planet. What does the interior heat of the earth do for that region? The antarctic continent's perpetual covering of ice and snow is unaffected by it, nor does the actually enormous quantity of solar heat falling upon that continent suffice to remove the white mantle. If aught should intervene to cut off the sun's energy from the earth for one short month, the tropics would attain to a state of frigidity to which the south polar continent, as now observed, would be a rose garden in comparison.

It is the sun's heat which grows the farmer's crops, the trees of the forest and all vegetation. The coal deposits upon which we draw to-day for the running of trains, ships, factories and rolling mills, are but the solar energy of an earlier age, compressed, transformed and preserved for our comfort and power. In the mountainous regions of our

land, where water can be stored in high level reservoirs and, passing through water wheels at lower levels, be made to generate electric power for lighting, for heating and for the running of motors, it is the sun's energy which is transformed to meet the needs of men. The sun's rays evaporate the surface waters of the oceans, lakes, streams and lands; the winds, generated by the unequal solar heating of our atmosphere, transport some of the water vapor to the high mountains, where it is deposited as rain or snow. It is merely the descent of these waters to the lower levels that is controlled by man and transformed into electric power for his own purposes.

It would take more than two billion earths placed side by side to form a continuous spherical shell around our sun at distance equal to the earth's distance, and thus to receive the total output of solar heat. Therefore less than one two-billionth part of that output falls upon the earth. The earth's share of solar energy, expressed in horse-power or other familiar units, is too great to set down in figures. If you should happen to own 250 acres of land in one of the tropical deserts of the earth, you will be interested to know that your quota of the solar energy, near the middle of a summer day, is falling upon your tract of land at the rate of about one-million horse-power—more than enough heat and power to supply all the needs of this great city—and this is but two thirds of the sun's good intentions toward you, for some 40 per cent. of the energy is intercepted by the atmosphere overlying your farm, and returned forthwith to outer space.

Your neighbor's tract of 250 acres is also receiving solar energy at the rate of one million horse power. Figuring backward, if one farm area receives a million horse power, and there are more than a hundred million such farm areas on the earth turned toward the sun at one time, and the whole earth intercepts less than one two-billionth of the sun's energy output, is it any wonder that sun worship became one of the recognized religions? Accurate knowledge saves us from that, but it

is becoming in us to give the sun our due respect.

A great problem ahead of the scientific world is the storage of the sun's beneficent heat rays for release as needed. Astronomers are seeking intently for the sources of the sun's outpouring of energy: how can the sun maintain the supply for tens of millions of years, as it undoubtedly is doing? One important source has been found—the sun's own gravitation which tries constantly to pull every particle of its material to the sun's center—but another and greater source seems to await discovery. Does any one say, since the supply of solar energy will surely meet our needs for ten or a hundred million years, why look further for the cause? Why not let it go at that? This selfish spirit, if applied to all subjects, would retrograde our civilization. Even the possession of the truth is not so potent for good as the desire to know the truth, and the struggle to discover it. Practically, a knowledge of the origin of the sun's heat may be the key for locking up great quantities of it on summer days and unlocking it when and where needed.

Who is not interested in Mars, a planet much smaller than the earth, a little over four thousand miles in diameter, which revolves around the sun in somewhat less than two years, at an average distance from the sun fifty per cent. greater than the earth's distance? Mars is literally one of the earth's brothers, and we should be sincerely interested in his welfare. Does life exist on that planet? Almost certainly there is vegetable life. We have no reason to doubt it. Certain areas of the planet change in color as the climatic seasons come and go, very much as we should expect if these colors were controlled by the natural stages of vegetable life. However, in precaution, I should guard against the drawing of the conclusion that vegetable life on Mars has actually been proved to exist. I can merely say that we see no reason to doubt its existence. Is there animal life on Mars? There probably is, but we have no positive evidence that such is the case. If the physical conditions on the planet as to water, air



and soil are such that vegetable life may exist, the chances are strongly in favor of animal life also. However, I think we must leave unanswered for the present the question whether such animal life is highly intelligent. The forests of the St. Lawrence Valley and the prairies of the Mississippi Valley put on their green coats in the spring and changed them to brown coats in the fall, perhaps even better before the coming of man than after his destructive influence descended upon them. If you had the means to ascend several thousand miles above your present position, and could dwell there throughout the year, you would witness the formation of a polar snow cap upon the earth early in the autumn. The southern edge of this cap would extend farther and farther to the south up to the time of mid-winter. Its edge would extend well down toward the southern limits of the United States, to the Himalayas in Asia, and so on. With the coming of spring the north polar cap would decrease in size and probably disappear, save as to snows on the higher mountains and the possible ice and snows of the immediate polar region. An observer similarly situated above South America would witness similar phenomena as to the south polar regions; and these are indeed the phenomena observed on the planet Mars. The white polar caps on Mars wax and wane with the coming and going of the winter as they do upon the earth. Superficially, the Martian conditions seem not very different from the terrestrial, though we know that the Martian atmosphere is highly attenuated, and if we were suddenly set down upon that planet's surface we should certainly suffocate for lack of air. Water is probably scarce upon that planet in similar degree. However, these facts do not militate strongly against animal life upon that planet, for such life would undoubtedly be developed with respiratory and other organs adapted to their environment. A solution of the Martian problems, as to a possible counterpart of terrestrial man on that planet, is apparently not now hopeful, but present-day failures may be the prelude

to future successes, and I prefer to offer no discouragement.

The planet Venus, only a shade smaller than the earth, and but two thirds as far from the sun as we, presents a similar but apparently more difficult problem. We know that it has an extensive atmosphere, no doubt comparable with that of the earth, but concerning the presence of water we are justified in making no statement other than that we remain in apparently total ignorance. If Schiaparelli was right, as he appears to have been, that Venus always presents the same face to the sun, just as the moon always turns the same hemisphere toward the earth, then one hemisphere of Venus undoubtedly remains intensely hot in perpetuity, and the other hemisphere in perpetual darkness and excessively low temperature. Can the twilight zone between the hemispheres of day and night offer abode and comfort to living forms, vegetable and animal? We have found no answer to this question, and we know not how to progress to the solution.

Are the moon and Mercury inhabited? Certainly not by such forms of life as we are familiar with, for neither object has an appreciable atmosphere. Both bodies undoubtedly suffer from extremes of heat and cold, without the protecting blanket of atmosphere with which the earth is blessed. The other planets, Jupiter, Saturn, Uranus and Neptune, may be dismissed as uninhabitable by life forms of our acquaintance. There seems no reason to doubt that these great bodies, from four to eleven times the earth in diameter, are still devoid of solid footing for man or beast, such as the rock and soil strata afford upon the earth.

Have astronomers been able to prove that planets revolve around other suns than ours? No, the distances of the nearest stars preclude that possibility to our means in hand. Such planets would need to be many-fold brighter than Jupiter, the greatest of our planets, and our great telescopes would need multiplication many times in diameter to let us see them as attendants of their suns. We are able to prove, and have proved, however, the existence of

hundreds of bodies, in distant space, whose rays of light we have not perceived. The spectrograph has shown with certainty that, of the naked-eye stars, one in four on the average is not the single star which it appears to be to the naked eye, or when viewed in the telescope, but that it is a double sun, the two bodies revolving continuously about their mutual center of mass. These hundreds of binary systems are so far away that even under the highest telescopic magnification they blend into a common and essentially mathematical point. It is the expectation that the future, possibly the present century, will establish that one star in three, on the average, is a double solar system. It may even prove to be the truth that our solar system, consisting of one great central sun and many attendant planets, is not the average and prevailing system, but is the exception and not the rule. However, we have no good reason to doubt that tens of thousands, more probably tens of millions, of distant suns are the centers of planetary systems, and that countless planets are the abode of life. As our sun is but one of hundreds of millions of suns, it is absurd and essentially inconceivable that our planet, or two or three of our planets, should be the only bodies throughout the universe supporting life. It is vastly more probable that if our vision could penetrate to other stellar systems, lying in all directions from us, we should there find life in abundance, with degrees of intelligence and civilization from which we could learn much, and with which we could sympathize. The spectroscope proves absolutely that dozens of chemical elements in the earth's surface strata exist in our sun: that iron, the silicon of our rocks, hydrogen, helium, magnesium and so forth exist in the distant reaches of our stellar system. If there is a unity of materials, unity of laws governing those materials throughout the universe, why may we not speculate somewhat confidently upon life universal?

In the days of my youth, here in northern Ohio, the opinion prevailed throughout the community, and widely over the earth, that comets were the forerunners of wars, plagues or other forms of dire distress. Did not the

great comet of 1811 herald the war of 1812, and that of 1843 the Mexican War and Donati's comet of 1858 our Civil War? Even in the twentieth century the fear that a comet may collide with the earth and destroy its inhabitants comes to the surface, here and there, every time a comet is visible to the naked eye. The findings of astronomers concerning these visitors to our region of space have taught that we have nothing to fear from them, and that their close approaches may be welcomed, for they are interesting members of our sun's family. They revolve around our sun as the planets do, and render unto it homage and obedience. It is undoubtedly true that the earth has plunged through the tails of comets many a time and without appreciable effects upon our health and happiness. In fact, the inhabitants have at the time been blissfully unaware of the passage. It is true that a collision of the condensed head of the comet with the earth is not impossible; it may some time occur; but comprehensive studies of this question, based upon observational data concerning many of these bodies, lead indubitably to the conclusion that we must not expect these collisions to occur, on the average, more than once in 15 or 20 million years. The so-called shooting stars, which we have all observed in the night sky, are in many cases, perhaps in all, though we do not know, the burning of minute pieces of comets which have disintegrated and disappeared as comets forever from our sight. Colliding with the earth, rushing through the upper strata of our atmosphere with speeds up to 40 or more miles per second, the frictional resistance of the air heats them to the burning point, and they are turned into ashes and the vapors of combustion. A very few get through to the earth's surface and are found and placed in our museums. It is not certain that any of those in the museums are parts of disintegrated comets, but some of them probably are. The number of small foreign bodies which collide with our planet every day is very great; a conservative estimate is 20,000,000. Except for our beneficent atmosphere man would suffer many tragedies from the bombardment. There is reason to believe that the earth is



growing larger very slowly, from these accretions, and this may have been the process by which the earth grew from a small nuclear beginning up to its present size.

Astronomers have determined that our solar system is very completely isolated in space. We are widely separated from our neighbors. I shall not try your patience by quoting the tremendous distances in miles, for they are incomprehensible to all of us. Rays of light sent out by the sun require a little more than eight minutes to reach the earth. The outermost known planet in our system, Neptune, would be reached in four hours and a half. Rays of light leaving the sun at the same time and travelling at the same rate, 186,000 miles per second, must travel continuously during four years and a half to reach our nearest known neighbor in space, the bright double star Alpha Centauri. If the distance from the sun to the earth is 1, the distance to our outer planet is 30, and the distance to Alpha Centauri is 275,000. There appears to be an abundance of room in the great stellar system to meet the requirements of all. The spectrograph attached to the Lick telescope has determined that our sun and its family of planets is traveling through the great stellar system with a speed of twelve and a half miles per second, equivalent to four hundred million miles per year. The earth is certainly hundreds of millions of years in age, the sun is no doubt at least as old, and the early youth of the earth was lived, not where we now are, but far elsewhere in the stellar system; and its future journeyings will lead to quite other points of observation.

The question of greatest interest to present-day astronomers is that of stellar systems other than our own. The chances seem strong that the hundreds of thousands of spiral nebulae known to exist in very distant space are other and independent systems of stars, many of them perhaps containing as many stars as our stellar systems. In other words, our stellar system may be but one of hundreds of thousands of isolated stellar systems distributed through endless space. This is not an estab-

lished fact, but the evidence seems to run in its favor.

I have referred to some of the problems and results of astronomical science. The list of interesting items is a long one, but available time has its limits. In brief, it is the astronomer's duty to discover the truth about his surroundings in space, and make it a part of the knowledge of his day and generation. The ultimate and real value of his work lies in its influence upon the lives of the people of the world, in the changes for the better which it induces in their modes of thought, and in the impulse which it gives to an advancing civilization.

Would that the attractions of the sky to the average man were more potent. It is a curious comment upon the attributes of city life that hundreds of thousands of people, especially children, in London and Paris, in the darkness which gave them semi-concealment from the enemy's destructive air ships, should have obtained their first real vision of the starry heavens. What must have been their sensations? On the other hand, those who can view its beauties and wonders are prone to neglect it; to look down instead of up. Emerson has said somewhere in his immortal essays that if our sky should be clear of clouds but one night in a century, the people of this globe would look forward to the rare event, and not only prepare to behold its beauties themselves, but make sure that their friends far and wide were likewise minded. How the beauties of the night sky would surpass the expectations of the most lively imagination! The wondrous vision would be the prevailing subject of conversation for years and years, and the repetition of the vision, one hundred years later, would need no advertising.

Our knowledge of the heavens is in its infancy. We have but made a start upon the discovery of the truth about the stars, and the results of astronomical research are not so widely known amongst the people as they should be. This splendid institution, The Warner & Swasey Observatory, presented by men who are masters in telescope and observatory design and construction, by men who

have thought much of relative values in life, this institution has a field of great usefulness lying before it. In their administration of the generous gift, the trustees, the president and the faculty of the Case School of Applied Science, whether for research, for school instruction or for community education, will have the sympathetic interest of astronomers, of all lovers of the truth. This observatory may assist in the solution of important problems concerning the universe of which we form a part. The universities, the colleges and the technical schools of our country, and of other countries, are graduating every year many hundreds of young men, ready to start upon the more serious phases of their lives, who can tell us all about the lights in our houses, but not one word about the lights in our sky. This institution will do its quota in approximating to a liberal education. The casual visitor who enters its portals in search of knowledge, yea, the passer-by in the street who merely sees a dignified and purposeful observatory set upon a hill, will have his thoughts directed to higher levels.

W. W. CAMPBELL

LICK OBSERVATORY,  
UNIVERSITY OF CALIFORNIA

#### PLAN OF THE BICENTENARY EXPEDITION TO THE NORTH OF GREENLAND

IN the year 1721 Hans Egede left Copenhagen for Greenland; with this event the systematic colonization of the vast arctic territory by the Danish State began. In celebrating the bicentenary of this colonization it is natural not only to review what has been achieved, but also to look forward to what still remains to be done both in administration and in research.

The whole coast-line of Greenland is now known. Every point of the coast, extensive as that of a continent, commemorates by its name the glorious achievements of explorers. As a rule, the big nations were before us as far as the discovery itself was concerned, but we may safely say that Danish research

has deepened and perfected the knowledge of the new coast-lines. Stubbornly and unweariedly we have carried our flag to the North on both coasts.

The coast of Peary Land, the remotest, most inaccessible part of Greenland we have reached from both sides. The "Danmark" Expedition reached Peary's Cairn on Cape Bridgeman and the Second Thule Expedition, in which I took part myself, reached the De Long Fiord. There still remains a stretch of coast which no Dane has ever seen, and the interior of this country, almost as large as Denmark, is absolutely unknown.

On the Second Thule Expedition, conducted by Knud Rasmussen, it fell to me not only to map out great ice-free territories, which had hitherto been unknown, but also to demonstrate that these new territories are geologically among the most interesting in Greenland, and that the so-called Caledonian Fold, which had hitherto been known to exist only in northern Europe stretched across to the other side of the Atlantic.

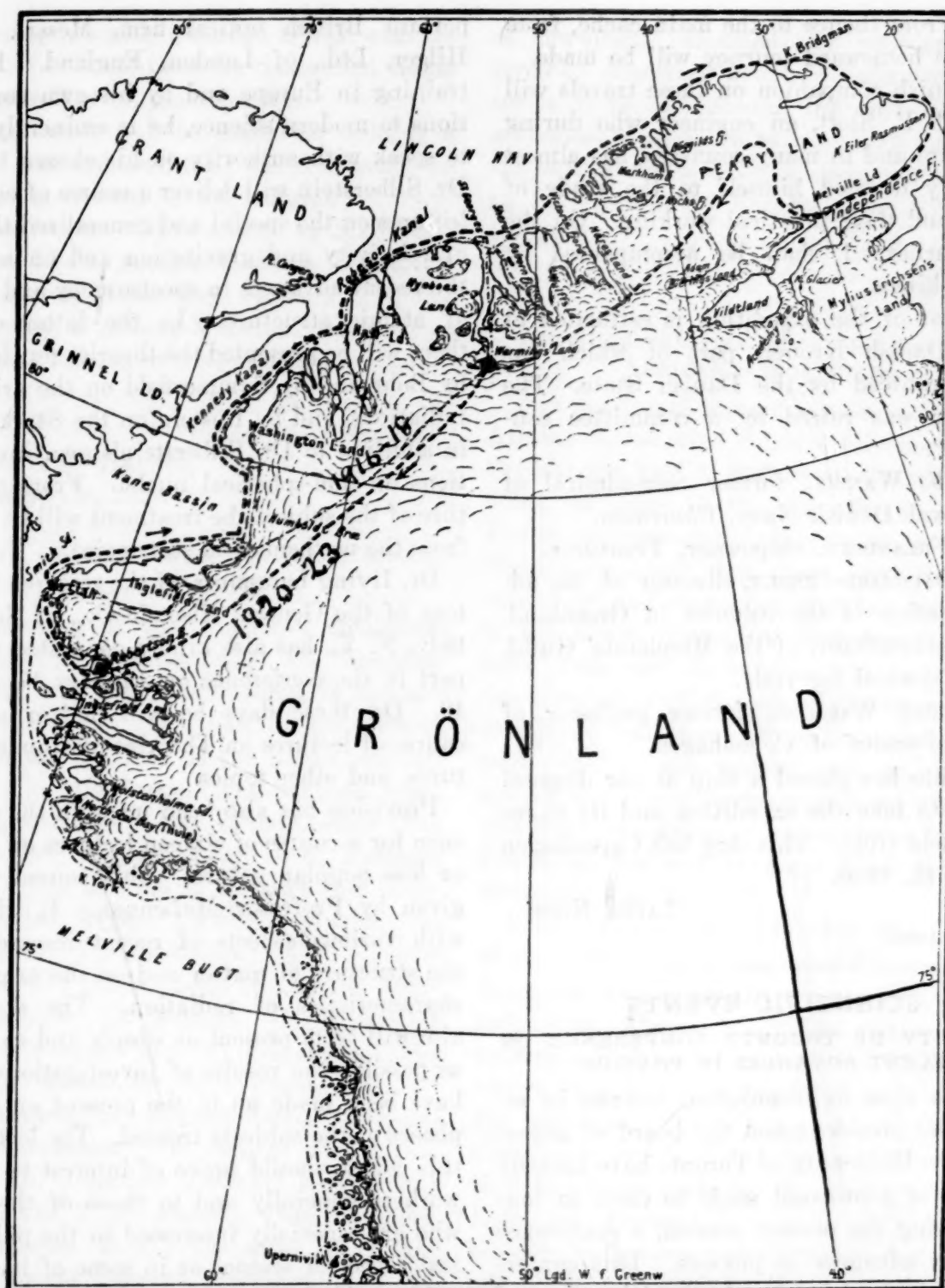
Though our results are confirmed by the collections which we succeeded in bringing home in spite of the greatest difficulties, I realized even while working in the field, that great problems still remained to be solved. Another expedition is planned the aim of which will be exclusively geological and geographical research.

Headquarters with a wintering station will be established in Robertson Bay in Inglefield Gulf. From here the following expeditions will be made:

1. A large provision cache for future journeys is to be taken across the Inland Ice from Inglefield Gulf to Warming's Land.<sup>1</sup> The transport will take place in the late summer, when the temperature is comparatively high and the surface snow is melted down or compressed. For this reason it is to be undertaken by Cleveland Tractors, which will be able to work across the ice-free marginal zone at Inglefield Gulf.

<sup>1</sup> South of Sherard Osborne Fiord. The writer's map of the regions surveyed by the Thule Expedition has been printed and will soon be published.





2. The next year the same journey will be repeated in dog-sledges to the cache and from there to the interior of Peary Land and to the north of Adam Bierings Land, an advanced base being established in Valmuedalen, from which various short journeys will be undertaken: to Independence Fiord where Mylius Erichsen's account of his journey is to be found, and northwards to Böggild's

Fiord. On the way back, the part of Wulff's Land and Warming's Land, which I did not succeed in mapping out on the second Thule Expedition, will be surveyed. The main cache will be passed on the way back in August.

3. The following spring it is planned to proceed from headquarters along the coast, through Robeson Channel and further to the north of Peary's Land into Independence

Fiord. From thence to the main cache, from which the homeward journey will be made.

My Danish companion on these travels will be Mr. C. F. Slott, an engineer who during many years and in many countries has almost exclusively devoted himself to the study of tractors and their practical working. On the sledge-journeys I shall be accompanied by Polar Eskimos.

The cost of the expedition is estimated at 110,000 Danish Kroner, part of which has been guaranteed by the Danish State. The remainder was raised by a committee consisting of:

MR. C. F. WANDEL, former rear-admiral of the Royal Danish Navy, *Chairman*.

MR. A. ERLANDSEN, shipowner, *Treasurer*.

MR. J. DAUGAARD-JENSEN, director of the administration of the colonies in Greenland.

MR. V. GLÜCKSTADT, of the Merchants' Guild, consul general for Italy.

MR. EUGENE WARMING, former professor of the University of Copenhagen.

The state has placed a ship at our disposal in order to take the expedition and its stores to Inglefield Gulf. This ship left Copenhagen on July 15, 1920.

LAUGE KOCH

COPENHAGEN

#### SCIENTIFIC EVENTS

##### UNIVERSITY OF TORONTO CONFERENCE ON RECENT ADVANCES IN PHYSICS

WITH a view to stimulating interest in research, the president and the board of governors of the University of Toronto have heartily approved of a proposal made to them to convene, during the present session, a conference on recent advances in physics. This conference will be held in the physics laboratory of the university between January 5 and 26, 1921.

Dr. Ludwik Silberstein, late professor in the University of Rome, and at present mathematical adviser to the Eastman Kodak Co., of Rochester, N. Y., has kindly consented to take the leading part in the conference. Dr. Silberstein is a distinguished mathematician and mathematical physicist and, during the period of the war, served as expert adviser to the im-

portant British optical firm, Messrs. Adam Hilger, Ltd., of London, England. By his training in Europe and by his own contributions to modern science, he is eminently fitted to speak with authority on his chosen themes. Dr. Silberstein will deliver a course of eighteen lectures on the special and generalized theories of relativity and gravitation and on some of the recent advances in spectroscopy and theory of atomic structure. In the latter courses there will be presented the theories put forward by Bohr and by Sommerfeld on the origin of radiations, and by Epstein on the Stark effect, in addition to Dr. Silberstein's own investigations on non-spherical nuclei. From the nature of the subject the treatment will be chiefly from the mathematical standpoint.

Dr. Irving Langmuir, of the research laboratory of the General Electric Co., of Schenectady, N. Y., has also kindly consented to take part in the conference on January 17, 18 and 19. On these days he will deliver a short course of lectures on Theories of atomic structures, and other topics.

Provision has also been made in the conference for a course of sixteen lectures on a more or less popular nature. This course will be given by Professor McLennan. It will deal with various aspects of recent researches on the structure of matter and on the origin and characteristics of radiation. The dominant aim will be to present as simply and as clearly as possible the results of investigations which have been made up to the present on various phases of the subjects treated. The lectures of this course should prove of interest to science workers generally and to those of the public who are especially interested in the philosophical aspect of science or in some of its important applications.

A course of lectures will also be given on the fundamental properties of colloidal solutions. More and more in industry is a knowledge of colloids and their chemical properties becoming essential and it is expected that these lectures will prove interesting and profitable to manufacturers as well as to scientific workers. Professor E. F. Burton, both on account of his investigations in this subject and from



his training is highly qualified to deal with the subjects of colloids from its theoretical standpoint, as well as its practical side.

Arrangements will be made for holding a series of discussions during the conference on the subjects treated in the lectures.

The conference will be opened by Sir Robert Falconer, LL.D., president of the University of Toronto, on Wednesday, January 5, at five o'clock, when Professor McLennan will deliver the opening lecture on "Molecules and atoms."

J. C. McLENNAN,  
*Professor of Physics*

UNIVERSITY OF TORONTO,  
November 22, 1920

#### MEETING OF THE AMERICAN ORNITHOLOGISTS' UNION

THE meeting of the American Ornithologists' Union in Washington, D. C., November 8-11, 1920, was one of the largest in the history of the union. One half of the Fellows and about ten per cent. of the entire membership were in attendance. The business meetings on Monday were held at the Cosmos Club and the other sessions at the U. S. National Museum. The election of Fellows and Members included Robert Cushman Murphy, of Brooklyn, N. Y., as Fellow; E. C. Stuart Baker and Dr. Percy Lowe, of London, Honorary Fellows; 13 Foreign Corresponding Fellows; 5 Members and 307 Associates. The election of officers for 1921 resulted as follows: President, Dr. Witmer Stone, Philadelphia; Vice-president, Dr. George Bird Grinnell and Dr. Jonathan Dwight, New York; Secretary, Dr. T. S. Palmer, 1939 Biltmore St., Washington, D. C.; Treasurer, W. L. McAtee, Biological Survey, Washington, D. C. The single vacancy in the council was filled by the selection of Dr. W. H. Osgood, of Chicago, and the other six members were re-elected. The program of nearly 40 papers, five of which were illustrated by motion pictures, covered a wide range of subjects relating to North American birds and also included papers on the birds of Argentina, Nicaragua, Peru, Europe and Madagascar. In connection with the meeting an exhibition

of drawings, paintings and photographs of birds by American artists, supplemented by a series of prints showing the development of zoological illustration as applied to birds from the earliest times down to date, was arranged in the Division of Prints in the Library of Congress.

T. S. PALMER,  
*Secretary*

#### THE BULAWAYO MEETING OF THE SOUTH AFRICAN ASSOCIATION

THE eighteenth annual session of the South African Association for the Advancement of Science was held in Bulawayo, Southern Rhodesia, on July 14-17, with Dr. I. B. Pole Evans, as president. From the report in *Nature* we learn that there were the usual receptions and functions, together with visits to the Khami ruins, the Matoppos, the Victoria Falls and Livingstone. A party, after the conclusion of the official meeting, visited the Great Zimbabwe. More than sixty papers were read in the various sections, and the attendance was a large one more than 130 members proceeding by special train from the Transvaal, as well as some from the Cape Peninsula and Natal.

The president Dr. I. B. Pole Evans, chief of the Division of Botany and director of the Botanical Survey of the Union, gave a most interesting address on "The veld: its resources and dangers," the address being illustrated by a series of beautiful lantern-slides. He reviewed recent progress in botanical knowledge, and outlined the notable advance that had been made by the members of the Botanical Survey in respect to systematic ecology, indigenous grasses, fungi and poisonous plants. Mr. H. E. Wood, of the Union Observatory, Johannesburg, as president of Section A, gave an address on "Recent progress in astronomy," noting that the present year was the centenary of the foundation of the Royal Observatory at the Cape. "Geology in relation to mining" was the subject of the presidential address to Section B, given by Mr. F. P. Mennell, who has seen all the later developments in the mining industry of Rhodesia. Dr. T. R. Sim, late government

forester in Natal, delivered the presidential address to Section C on "Causes leading towards progressive evolution of the flora of South Africa." In Section D the presidential address was delivered by Mr. C. W. Mally, Cape Entomologist, whose subject was "Some zoological factors in the economic development of South Africa." The Rev. H. A. Junod, president of Section E, gave a most interesting address on "The magic conception of nature among Bantus." "Labor conditions in South Africa" was the subject of Professor R. Lehfeldt's presidential address to Section F. An evening lecture was delivered by Professor J. A. Wilkinson on "The nitrogen problem."

The South African medal and grant were awarded to Professor E. Warren. Johannesburg is now the seat of the headquarters of the association, and the next meeting will be held at Durban in July, 1921.

#### SCIENTIFIC NOTES AND NEWS

At the anniversary meeting of the Royal Society on November 30 the following medals were conferred by the retiring president, Sir Joseph Thomson: A Royal medal to Mr. W. Bateson, for his contributions to biological science, especially his studies in genetics, and a Royal medal to Professor G. H. Hardy, for his researches in pure mathematics, particularly in the analytic theory of numbers; the Copley medal to Mr. H. T. Brown, for his work on the chemistry of carbohydrates, on the assimilation of atmospheric carbon dioxide by leaves, and on gaseous diffusion through small apertures; the Rumford medal to Lord Rayleigh, for researches into the properties of gases at high vacua; the Davy medal to Mr. C. T. Heycock, for his work in physical chemistry, especially on the composition and constitution of alloys; the Darwin medal to Professor R. H. Biffen, for his work on scientific principles applied to the breeding of plants; and the Hughes medal to Professor O. W. Richardson, for his work in experimental physics, especially thermionics.

At the meeting of the Geographical Society of Philadelphia, held on December 1, the

Elisha Kent Kane gold medal of the society was conferred on Dr. A. Hamilton Rice in recognition of his pioneer exploratory work in South America.

THE Franklin Institute of the State of Pennsylvania acting through its committee on science and the arts, at its meeting on November 17, 1920, awarded to Dr. W. L. R. Emmet, of Schenectady, its Elliott Cresson Gold Medal. The wording of the award is as follows: "After a careful consideration and study of Dr. Emmet's work relating to ship propulsion, the institute is of the opinion that it deserves the highest award in its gift for the recognition of inventions of signal importance and awards to Dr. W. L. R. Emmet the Elliott Cresson Medal in recognition of his notable contributions to the art of ship propulsion!"

THE gold medal of the British Institution of Mining and Metallurgy, has been awarded to Sir Thomas Kirke Rose "in recognition of his eminent services in the advancement of metallurgical science, with special reference to the metallurgy of gold."

SIR WILLIAM BEALE has been elected president of the Mineralogical Society, London.

DR. JAMES M. TAYLOR, since 1873 professor of mathematics at Colgate University, has retired from active service.

DR. JOHN B. WATSON has resigned from the professorship of psychology which he has held since 1908 at the Johns Hopkins University.

DR. D. R. HOOKER has resigned his position as associate professor of physiology in the Johns Hopkins Medical School, to engage entirely in research.

PROFESSOR C.-E. A. WINSLOW, of the Yale University School of Medicine, has been granted leave of absence for the spring term in order that he may assume the directorship of the public health activities of the League of Red Cross Societies at Geneva. Professor Winslow will return to New Haven for the opening of the fall term, October 1 next.

DR. ROBERT K. NABOURS, professor of zoology and experiment station zoologist in the



Kansas Agricultural College, has resumed his work, after a year's leave of absence, during which time he made a journey around the world pursuing investigations of the fur industry in various countries for Funsten Bros. and Company.

W. ARMSTRONG PRICE has resigned his position of paleontologist with the West Virginia Geological Survey and is now in Tampico as geologist with the Transcontinental Petroleum Company. He is accompanied by Lloyd C. Gibson, formerly geologist with the Seneca Hill Oil Company of West Virginia.

DR. HEBER D. CURTIS, director of the Allegheny Observatory, University of Pittsburgh, delivered the annual Sigma Xi lectures at the Universities of Kansas and Missouri, November 18 to 19. His general subject was, "Modern views of our sidereal universe." The first lecture was "The data of stellar evolution," and the second "The size of our universe."

DR. CARL J. WIGGERS, of the Western Reserve University, will deliver the fourth Harvey Society lecture at the New York Academy of Medicine, Saturday evening, December 11. His subject will be "The present status of cardio-dynamic studies on normal and pathological hearts."

DR. IVEY F. LEWIS, Miller professor of biology at the University of Virginia, made the address at the first public meeting of the newly formed Naturalists' Club of the University of Richmond, Va.

THE Huxley lecture was delivered in the Mason College, Birmingham, on November 26, by Professor C. S. Sherrington, whose subject was "The gateways of sense."

OWING to the continued ill-health of Mr. Spencer U. Pickering, which renders him unable to continue his experimental work at the Woburn Fruit Farm, which was carried on from 1894 to 1918 by the Duke of Bedford, and since then by means of a grant from the Development Fund administered by the committee of the Rothamsted Experimental Station, it is to be closed.

A NEW station for experimental biology has been founded at Schederlohe in the Isar val-

ley, Bavaria, by Dr. Curt B. Haniel, with the collaboration of Dr. Jacob Seiler, formerly assistant of Dr. Goldschmidt, at the Kaiser-Wilhelm Institute für Biologie, Berlin-Dahlem.

THE American Mathematical Society will, as usual, hold two meetings in the Christmas holidays. At the annual meeting in New York on December 28-29 the election of officers will take place and President Frank Morley will deliver his retiring address, the subject of which is "Pleasant questions and wonderful effects." The regular western meeting, which is also the meeting of the Chicago Section, will be held at Chicago, on December 29-30, in affiliation with that of the American Association for the Advancement of Science. Professor Arnold Dresden, of the University of Wisconsin, is secretary of the western meeting.

PROFESSOR JAMES F. NORRIS has been elected to the chairmanship of the committee in charge of the C. M. Warren Fund of the American Academy of Arts and Sciences, in place of Professor H. P. Talbot, resigned. The income from the fund is available for the "encouragement and advancement of research in the science or field of chemistry," and may be used to provide the materials required for such investigations or assistance in their execution. The committee will be glad to receive and consider requests for grants from this fund. They should be addressed to Professor James F. Norris, Massachusetts Institute of Technology, Cambridge, Massachusetts.

WE learn from *Nature* that a meeting of the International Commission for Weather Telegraphy, which was appointed by the International Meteorological Conference at Paris in October, 1919, was held at the Air Ministry, London, during the week November 22-27. The following delegates were expected to attend the meeting: Lieutenant-Colonel E. Gold (president), Meteorological Office, Air Ministry; M. A. Angot, Bureau Central Météorologique, Paris; Colonel L. F. Blandy, controller of communications, Air Ministry; Dr. van Bemmelen, Meteorological Observatory, Batavia; Colonel Delcambre, Service

Météorologique Militaire, Paris; Professor F. Eredia, Ufficio Central di Meteorologia, Rome; Professor E. van Everdingen, Meteorologisch Institut, De Bilt, Holland; General Ferrié, Minister of War, Paris; Captain Franck, Service de la Navigation Aérienne, Paris; Señor José Galbis, Sericio Meteorologico Español, Madrid; Lieutenant H. D. Grant, Meteorological Office, Aor Ministry; Dr. Hesselberg, Meteorologische Instituut, Christiana; Colonel Matteuzzi, Servizio Aerologico, Rome; Professor A. de Quervain, Central Meteorological Office, Zurich; M. Rey, Ministère de l'Agriculture, Paris; Captain C. Ryder, Meteorologische Institut, Copenhagen; Mr. T. Thorkelsson, Meteorological Service, Reykjavik; and Dr. A. Wallén, Meteorologiske Hydrografiske Anstalt, Stockholm. Since the war much progress has been made in different countries in the development of codes for telegraphic reports of the meteorological information which experience in the war and the needs of aerial navigation indicated as necessary. The main object of the commission is to coordinate these developments in the revision and extension of the codes prepared at the last meeting of the commission, which was held in London in September, 1912.

THE Civil Service Commission announces an examination for ordnance research engineer at \$2,000 to \$5,000 a year, or higher or lower salaries. It also announces an examination for junior physicist in the Bureau of Mines, at \$1,500 to \$1,800 a year.

At the recent Chicago meeting of the American Mathematical Society the following resolution was passed: "The Society recommends for favorable consideration by the council applications for membership from advanced students and others interested in mathematics, whether engaged in teaching or not, when properly proposed by members of the Society."

DR. JONATHAN DWIGHT contributes the following note to the *Journal* of the New York Botanical Garden on the Linnaean Botanical Garden, at Upsala, Sweden: In the lower end of Svartbacksgatan at Upsala is the old botanical garden of Carl von Linné which has been

nearly abandoned for about a century. This was the spot where the Flower-King spent most of his time among the plants, etc., where the grass thrived and trees grew tall. The Egyptian Antiquities from the Victorian Museum have reposed there for some time in part in his hothouse and part in the Museum for Northern Antiquities. A change has of late taken place in the old garden. Some of the old trees have been cut down, the well cultivated lawns are elevated, and Linné's lily ponds (which are seen in old copperplate engravings of his "*Hortus Upsaliensis*") have been rebuilt in their location. The young men of the old Linnean Society have accomplished this change and renovation. Linné's greenhouse and the foreground have as yet not been restored. This fall, however, the Museum of Northern Antiquities will be moved to "Gustavianum" and then the house will be arranged for a Linnean Museum. Professor Svedelius informs the public that a large donation has been received by the Linnean Society for a new home for the director. As soon as it is ready the Linnean Society will take possession, and also of the Linné House, where the extensive collections of furniture, books, bric-a-brac, etc., which were the belongings of Linné will then be moved. The greater portion of these have been heretofore kept in the Linné house in Svartbacksgatan.

#### UNIVERSITY AND EDUCATIONAL NEWS

THE University of Cincinnati has received from the General Education Board of New York, an offer to contribute \$700,000 to the Medical College. The gift is conditioned upon the raising of an additional \$1,300,000 to complete the \$2,000,000 endowment fund of the college; \$900,000 of this amount has been subscribed.

WE learn from *Nature* that Professor James Mark Baldwin, formerly professor of psychology in the Johns Hopkins University, has offered to pay for the present, in honor of his friend, Professor Poulton, an annual sum of £100 into a fund to be called "The Edward



Bagnall Poulton Fund," to be applied at the discretion of the Hope professor of zoology at the University of Oxford, in the promotion of the study of evolution, organic and social. Professor Baldwin has also announced his intention of leaving by will money for the sustentation of such a fund.

DR. D. A. ROTHROCK, professor of mathematics, has been elected dean of the college of liberal arts of Indiana University.

PROFESSOR H. E. HAYDEN, JR., formerly associate professor of biology in the A. & M. College of Texas, is now professor of biology in the University of Richmond, Va. Mr. Paul R. Merriman has recently been added to the staff as associate professor of botany.

DR. JOHN STEPHENSON, until recently professor of zoology in Government College, Lahore, has been appointed lecturer in zoology in the University of Edinburgh.

## DISCUSSION AND CORRESPONDENCE

### POSITIVE RAY ANALYSIS OF MAGNESIUM

USING the apparatus for positive ray analysis described in *The Physical Review* for April, 1918, I have recently succeeded in analyzing the element magnesium (atomic weight 24.36) into three isotopes of atomic weights 24, 25 and 26. The method is an adaptation to positive rays of a method previously used for measuring the ratio of charge to mass for electrons. The three components of magnesium appear suddenly together as the magnesium anode is heated to vaporize slightly. Their masses may be compared accurately with the molecule of mass 28 due either to occluded nitrogen or carbon monoxide, which is driven off at lower temperatures. The method also gives the relative amounts of the rays; the components at 25 and 26 are of about equal intensity, and that at 24 approximately six times as strong as the others. The average atomic weight 24.375 agrees as closely as is to be expected in these first experiments with the chemical atomic weight.

A. G. DEMPSTER

RYERSON PHYSICAL LABORATORY,  
UNIVERSITY OF CHICAGO

### ON RECORDING APPARATUS FOR METEOROLOGICAL RESEARCH WITH ROCKETS

MR. S. P. FERGUSON of the Weather Bureau has recently published several ingenious suggestions regarding the development of recording apparatus free from pivots, and hence useful in devices that are subject to jar. These suggestions are described in the *Monthly Weather Review* for June, 1920, pp. 321-322.

In this connection it is worth while remarking that tests with the model at present being made, using a mass carrying a recording pencil and held by a spring, show that the jar need at no time during the ascent be greater than would be experienced by a body striking the ground from a fall of 31 inches. This figure may be considered as representative of practical working conditions, but it is the jar, however, without any springs or shock-absorbing devices to protect the instruments.

Recording instruments for this particular work may be divided into two classes: First, instruments recording temperature, pressure and humidity by means other than the use of pivots, as already mentioned, the recording taking place both during ascent and descent. If records are to be had during the ascent, however, care must be taken so to support the various masses that there is no tendency to vibrate in a vertical plane. In general, this will not be a simple matter.

To the second class of instruments belong those involving the use of pivots which are kept separated from the bearings until automatically brought into contact when the descent begins, or at least after the propelling impulses have ceased. Instruments of this type need not differ fundamentally from devices at present in use, except that any considerable moments of force on delicate parts should be avoided.

R. H. GODDARD

CLARK COLLEGE

### THE HISTORY OF SCIENCE SECTION AND THE PROGRESS OF SCIENCE

TO THE EDITOR OF SCIENCE: In view of the approaching meeting of the American Asso-

ciation for the Advancement of Science, to be held in Chicago on December 27 to January 1, with its anticipated large attendance of sections and affiliated scientific societies, it is desirable to call attention to the fact that a symposium of papers or conference upon the History of Science will be held.

It is desirable at this time, also to formulate some plan for reorganizing section "L" to be known in time as the History of Science section, and to receive the report of the executive committee of the Council of the Association relative to the original plan of the History of Science section, to whom application and letters of endorsement have been sent.

It is also an appropriate time for those interested in this field of research and study to give some expression for a more progressive and effective means of advancement, which can only be done by cooperation through a well organized section.

The idea of the formation of an organization of this sort has been in the minds of the students of the history of science for some few years. During the early part of 1919 a number of communications were published in *SCIENCE*<sup>1</sup> advocating the desirability of such a section, and, urgent as the communications were, no action was taken. However, the Executive Committee of the Council is quite ready to do all in its power to the furtherance of this movement, providing a sufficient demand is forthcoming. Therefore, it is greatly desired that all those interested in this proposed section, express themselves in some definite manner, preferably by being present at the symposium at the Chicago meeting.

From the very foundation of the Royal Society of London, in 1662, cooperation was the prevailing spirit; which gave strength and impetus to further scientific progress. Our

<sup>1</sup> *SCIENCE*, N. S., Vol. XLI., March 5, 1915, pp. 358-360; Vol. XLIX., April 4, 1919, pp. 330-331; Vol. XLIX., May 9, 1919, pp. 447-448; Vol. XLIX., May 9, 1919, pp. 447-448; Vol. XLIX., May 23, 1919, p. 497; Vol. XLIX., July 18, 1919, pp. 66-68.

own venerable institutions, namely: The American Philosophical Society and American Academy of Arts and Science, founded in the intellectual and scientific centers of Colonial life, were also imbued with the principle of cooperation, which laid the foundation of America's preeminence in science to-day. The National Research Council is in itself the highest spirit of cooperation. In fact, all scientific and literary societies realize the value of cooperation. It is, therefore, only too evident what note cooperation plays in the history of science, and the same idea must prevail in the study and research in the history.

Heretofore the development and encouragement of the study of the History of Science has been left solely to individual efforts, and much remains to be accomplished if the subject is to have the same relative standing as the study of physics, chemistry, astronomy and other divisions of the sciences. The question of a new section among the already large number of sections affiliated with the American Association for the Advancement of Science is not a cause for amazement—quite to the contrary, but one indicating a healthy state of intellectual growth—in science, and to the "Association."

That we need more historical background for our ever growing technical subjects is so apparent to scholars that no further recognition of this fact will be taken here. Nor do we need to dwell upon the place science occupies in the history of civilization. What we are interested in wholly at present is the subject itself, in the field of scholarship and the need for a more decisive impulse and sympathetic understanding.

In the spirit and faith of a modern Humanist, who says:<sup>2</sup>

It is true that most men of letters, and, I am sorry to add, not a few scientists, know science only by its material achievements, but ignore its spirit and see neither its internal beauty nor the beauty it extracts continually from the bosom of nature. Now I would say that to find in the

<sup>2</sup> Dr. George Sarton, "The Faith of a Humanist," *Isis*, No. 7, Tome III., January, 1920, p. 5.



works of science of the past, that which is not and can not be superseded, is perhaps the most important part of our own quest. A true humanist must know the life of science as he knows the life of art and the life of religion.

The life of a science is not its daily practice in technic, building theories, testing hypotheses and handling results as worth so much—it is the story of trials and errors—the struggle of the mind for new concepts of nature and man's relation to this progress, and in the words of another true humanist,<sup>3</sup>

The student should be led to see that human history is a continuous process, not a succession of catastrophes. The real growth of humanity takes place in quiet; by war it is interrupted or reversed. For war is never the motive force of progress, and the spread of great ideas is not often facilitated by it. The forward trend of civilization is largely conditioned on science—itsself a product of peace.

With each new advance in science, each phenomenon of event shows only too conclusively how closely knit is the history of the discovery bound up with it, that no discussion of the theory or final result can be clear without its antecedent proceeding. The evolution of scientific progress clearly shows that there is no finality in science. The recent work in "Relativity and Gravitation" is the best example of concomitancy of theory and history—from the philosophical concept of the Greeks, to the present most rigorous and complex mathematical and physical understanding of Einstein's theory. The whole field of physical science has been reset with historical importance which has never been realized since Newton.

And surely our own progress in science in America warrants us to become more introspective, namely—viewing the present in the light of the past. If we are to have a distinct type of culture, worthy of any great intellectual epoch, it must depend upon our ability for introspection. To this end, then, it is interesting to note, that throughout the country there is awakening a new interest

<sup>3</sup> David Starr Jordan, "Building for the Future," *The Public*, May 3, 1919, p. 462.

in the history of science. This movement is but natural and in conformity with the growth of science progress itself.

Some few years ago it was pointed out to what extent the interest in the history of science had grown, especially as an educational factor in our colleges and universities.<sup>4</sup> Fortunately the "great war" has not lessened the interest, but it may have retarded the developments.

From a recent survey over practically the same field of investigation, it is extremely encouraging to note a few prominent features of this development. These facts will be given in order that a clearer understanding may be had for one of the many reasons why the History of Science work should be organized to form section "L" (Historical and Philological Sciences). Heretofore section "L" has not functioned, so that the field is open for organization and for productivity.

The most prominent and effective step in this growing movement was the establishment of a full professorship at the University of California in 1918 in the history of mathematics. The well-known scholar and historian of mathematics, Dr. Florian Cajori, has for two years offered courses in the history of mathematics and history of physics, besides for graduate work two seminar courses are offered in the history of algebra and of infinite series.

The next forward step of equal importance was the establishment of the post of research scholar in the history of science in the Carnegie Institution of Washington. The new position (Associate in the History of Science) was eminently filled by the appointment of Dr. George Sarton, who has for the last few years been offering courses in the history of science in Harvard University. From an extract concerning Dr. Sarton's work<sup>5</sup> it is of value to note the importance the authorities of the Carnegie Institution place upon the future of this movement.

<sup>4</sup> SCIENCE, N. S., Vol. XLII., No. 1091, pages 746-760, November 26, 1915.

<sup>5</sup> Year Book No. 18, Carnegie Institution, Washington, D. C. (1919), pages 347-349.

In recognition of the fact that the progress of astronomy in America has made magnificent contributions to that science, it is befitting that we should find in the oldest school for astronomical graduate work a course pertaining to the history of astronomy in America. The Detroit Observatory of the University of Michigan has in itself a wonderful history, in respect to training astronomers who have all been leaders in astronomical research. Dr. W. Carl Rufus's work in the history of astronomy consists of two courses—the first being the general history of astronomy and the second following with the history of astronomy in America. The second course is of particular interest to us now, since it is building the framework upon which the history of science in America must rest.

A cooperative course in the history of science is now being offered for the first time at the Northwestern University. It is given in two divisions, namely: the history of the physical sciences, given by Dr. Henry Crew, and the history of the biological sciences, by Dr. William A. Locy.

We may venture here to state that this form or division of the history of science teaching is probably the most satisfactory form in which to conduct the whole subject, since it is becoming more apparent that no single individual will be able to teach the subject as a whole.

At the University of Chicago we find a rather unique institution in the form of two historical courses being offered in the correspondence-study department by Dr. G. W. Myers. The history of mathematics and the history of astronomy are given primarily with emphasis placed upon the cultural value. Aside from the regular established course in the history of mathematics and biology, and a new course being offered in the history of astronomy, Yale University has announced a series of public lectures in the history of science.<sup>6</sup> These lectures clearly emphasize this growing movement for a more sympathetic understanding of the past, a regard for the past

<sup>6</sup> SCIENCE, N. S., Vol. LII., No. 1347, p. 383-384, October 22, 1920.

human relationship of those whose labors have prepared the way.

And, finally, it is to be accepted as a recognition of the worth and importance of the history of science when we read of the successful conference the American Historical Association carried on in December, 1919.<sup>7</sup> The interest the historian of the social and political sciences has in the history of science, is decidedly different from the historian of the sciences themselves. One may be termed the cultural interest, whereas the other is the technical interest. That is, the former is interested in the history of science from the point of view of methodology and the influence science has had on civilization—the latter is mainly concerned in the development of the concepts in science, and the growth of the subject matter and its influence upon related problems. It is evident that the interest can be, with profit, fostered by two widely different organizations, which never meet in common.

Such has been the progress of the movement to cultivate the history of science in the United States within the last few years. The remarks concerning these various steps of the progress are necessarily brief, but sufficient has been quoted to indicate that a new cultural epoch in the intellectual history of America is dawning. This cultural epoch must, from the very fact of its influence and interpretation, come to be known as the "new Humanism."

FREDERICK E. BRASCH

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#### SPECIAL ARTICLES

##### OPTIMUM NUTRIENT SOLUTIONS FOR PLANTS

DURING recent years numerous investigators have devoted considerable time and resources to the study of the salt requirements of various plants. Plans have been proposed for the extension of this work, with the hope that certain fundamental data may be obtained which shall indicate the composition and concentra-

<sup>7</sup> SCIENCE, N. S., Vol. LI., No. 1312, pages 193-194, February 20, 1920.



tion of the solution or solutions best suited to the growth of the plant. It now seems to be an opportune time to raise the following questions: first, is it probable that the plant has any definite response within broad limits, to a particular ratio of salts or ions contained in the complete nutrient solution; and second, assuming the existence of such optimum solutions, are the methods generally employed adequate to determine their composition?

With regard to the second point, in a previous communication the writer<sup>1</sup> has attempted to show that in many experiments the total supply of nutrients may have limited the yield of crop, rather than the salt proportion. In another article<sup>2</sup> it is shown that insufficient attention has been given to the possible limitation on growth with certain solutions, due to the insolubility of iron, when this element is added in the form of the phosphate. Recent work by Waynick<sup>3</sup> and Davis<sup>4</sup> has emphasized the necessity for inter-

may be suggestive in connection with the first point mentioned in this note. Three series of nutrient solutions were prepared:<sup>5</sup>

(a) Solution used by the author.

(b) Shive's best solution,  $R_5C_2$ .

(c) Shive's solution diluted to 1/3 of its concentration in *b*.

In each case 15 barley plants were grown for six weeks under favorable and uniform conditions of sunlight. The containers were of one liter capacity and only one plant was grown in each bottle. The solutions were changed weekly. Thus the total volume of solution provided for each plant was considerably larger than that used in most experiments of this type. Iron tartrate was added twice each week to all cultures. All the plants grew at a uniform rate and there was no apparent difference between the three sets at any time. The initial composition of the three solutions and the weights of the plants air dried were as follows:

Solution	Composition of Nutrient Solutions							Data on Plants				
	K, PPM.	Ca, PPM.	Mg, PPM.	PO <sub>4</sub> , PPM.	NO <sub>3</sub> , PPM.	SO <sub>4</sub> , PPM.	Total Concentration, PPM.	Total Weight Tops, Gms.	Total Weight Roots, Gms.	Average Length Tops, Cm.	Average Length Roots, Cm.	Ratio Tops Roots
a. (Author) .....	190	172	52	117	700	202	1,433	48.9 ± 7.5	8.4 ± 1.5	45 ± 3	30 ± 5	5.8
b. (Shive $R_5C_2$ ) .....	710	250	372	1,766	750	1,489	5,337	48.6 ± 8.5	7.8 ± 1.5	48 ± 3	26 ± 2	6.2
c. (Shive $R_5C_2$ ) 1/3.....	237	83	124	588	250	496	1,779	39.0 ± 4.5	7.4 ± 1.5	45 ± 3	25 ± 4	5.3

preting the data obtained in plant culture experiments with due consideration given to the variability of plants. In the majority of previous experiments this question has been almost completely overlooked.

During the course of an investigation on certain phases of plant nutrition, an incidental experiment has been carried out which

<sup>1</sup> D. R. Hoagland, *SCIENCE*, N. S., Vol. XLIX., pp. 360-362 (1919).

<sup>2</sup> D. R. Hoagland, *Jour. Agr. Res.*, Vol. XVIII., pp. 73-117 (1919).

<sup>3</sup> D. D. Waynick, *Ann. Rep. College of Agr., University of California*, 1918-19, p. 67.

<sup>4</sup> A. R. Davis, *Univ. of Calif. Pub. in Agr. Sci.* (in press).

<sup>5</sup> J. W. Shive, *Phys. Researches*, Vol. 1, pp. 327-397 (1915).

It is evident that solutions *a* and *b* produced equally favorable growth within the limits of error of this experiment, while the smaller yield from *c* is not necessarily significant, although in this case it is possible that the total supply of nitrate was insufficient. Thus in this experiment (a number of other experiments not now reported lead to the same conclusion) solutions of radically different concentrations and salt proportions have not affected the yield of the crop to any important extent. There is, however, no intention to give the impression that certain solutions (possibly including those containing large proportions of magnesium salts) may not inhibit plant growth because of unfavorable physiological balance. The point which

it is desired to make is that the range of equally favorable ratios between nutrient salts is probably a very broad one, no doubt including the solutions of most soils. This is not a surprising conclusion in view of the observation that under proper climatic conditions many different types of plants can grow vigorously on any fertile soil, while a given type of plant may grow equally well on various soils, the extracts of which have entirely different proportions of nutrients. Again, plants of equal development may store nutrient elements in very different ratios, when grown in different soils or solutions.

It has sometimes been suggested that solution and sand culture experiments offer a fundamental means of determining fertilizer requirements of soils, in connection with a proper physiological balance for the plant. If one considers the dynamic nature of the soil system, with its constantly fluctuating soil solution and the reactive properties of the soil minerals, it seems scarcely within the limits of possibility to alter a soil solution to fit any particular ratio of nutrients. The addition of any one fertilizer salt may affect all the various components of the soil solution. Moreover, many elements are present in the soil solution besides those added to the artificial culture solutions and it may not be assumed that these are without effect on the physiological balance of the solution, if indeed such a balance is of importance ordinarily.

D. R. HOAGLAND

DIVISION OF AGRICULTURAL CHEMISTRY,  
UNIVERSITY OF CALIFORNIA

#### THE AMERICAN CHEMICAL SOCIETY, CHICAGO MEETING

THE 60th meeting of the American Chemical Society was held in Chicago, Ill., Monday, September 6, to Friday, September 10, 1920. The council meeting was held on the 6th and a general meeting on September 7th, in the morning at the Congress Hotel, Chicago, and in the afternoon at Northwestern University, Evanston. Divisional meetings were held all Wednesday morning and all

day Thursday, and excursions Wednesday afternoon and Friday. Full details of the meeting and program will be found in the October issue of the *Journal of Industrial and Engineering Chemistry*. The registration was one thousand three hundred and eight.

The combined outdoor and indoor entertainment on the campus of Northwestern University on Tuesday afternoon was a new feature which met the hearty approval of all as it offered both a varied entertainment to the members and special opportunity for becoming acquainted.

General public addresses were given by Thomas E. Wilson, president, Wilson & Co., on "The value of technical training in the reconstruction of industries," and by Professor A. S. Loevenhart, head of the department of pharmacology of the University of Wisconsin, on "Chemistry's contribution to the life sciences." The chief public address was the president's annual address given by Dr. W. A. Noyes, in the Gold Room of the Congress Hotel, and was entitled, "Chemical publications." General addresses on Tuesday afternoon were given by H. P. Talbot on "Relation of educational institutions to the industries," and by W. A. Patrick on "Some uses of silica gels." The banquet, held on Thursday evening, September 9, filled the Gold Room of the Congress Hotel to overflowing. At the general opening session Charles L. Parsons reported on the International Conference of Pure and Applied Chemistry held in Rome, June 22 to 25, of which he was vice-president and to which he was a delegate from the American Chemical Society.

Abstracts of a larger part of this paper presented follows:

#### DIVISION OF BIOLOGICAL CHEMISTRY

R. A. Gortner, *chairman*,

A. W. Dox, *secretary*

*Diet and sex as factors in creatinuria in man:* HOWARD B. LEWIS and GENEVIEVE STEARNS. There appears to be no direct relation between the phases of the menstrual cycle and the appearance of creatine in the urine of the normal adult female. Protein *per se* is not a causal factor in the production of creatinuria and there is no more tendency toward the production of creatinuria by high protein diets during the menstrual than in the intermenstrual periods. The retention of creatine ingested *per os* by women does not differ markedly from that by men.



*The nutritive value of the proteins of tomato seed:* CARL O. JOHNS and A. J. FINKS. Nutrition experiments with albino rats have shown that normal growth can be obtained when the sole source of protein in a diet is furnished by tomato seed press cake. The protein content of the diet was approximately 18 per cent. and it was made adequate with respect to the non-protein dietary constituents.

*Hydrolysis of the globulin of the coconut, Cocos Nucifera:* D. BREESE JONES and CARL O. JOHNS. The globulin of the coconut has been hydrolyzed, and the resulting amino acids determined. By changing the order of procedure usually followed in connection with protein hydrolysis, and by applying several rather recently described methods, 78.15 per cent. of the hydrolysis products of the protein used has been identified and determined. The order of procedure followed in the isolation and determination of the amino acids was as follows: removal of the hexone bases with phosphotungstic acid: separation of most of the glutaminic acid as the hydrochloride: precipitation of the remaining dibasic amino acids as their calcium salts: extraction of proline and peptide anhydrides with absolute alcohol; esterification of the remaining amino acids by means of the lead salt method of F. W. Foreman: fractional distillation of the esters under reduced pressure, and finally, regeneration and isolation of the amino acids in the usual manner.

*The globulin of the cohune nut, Attalea Cohune:* CARL O. JOHNS and C. E. F. GERSDORFF. The globulin has been extracted and analyzed. Its analysis reveals a similarity to that of the coconut globulin. Like the coconut globulin it contains relatively high percentages of arginine and lysine, one half of the latter as determined by the Van Slyke method agrees fairly well with the free amino nitrogen of the protein. The globulin gives a strong test for tryptophane. A trace of albumin has been shown to be present.

*Some proteins from the mung bean, Phaseolus Aureus (Roxburgh):* C. O. JOHNS and H. C. WATERMAN. The Mung bean contains about 21.74 per cent. of protein ( $N \times 6.25$ ). Experiments with sodium chloride in various concentrations indicated a 5 per cent. solution as the most effective extractant; it dissolved 19.0 per cent. of protein from the finely ground seed. The saline extract yielded two globulins, designated the  $\alpha$ - and  $\beta$ -globulins, by fractional precipitation with

ammonium sulfate and by subsequent purification of the fractions as described. The yields were 0.35 per cent. and 5.75 per cent., respectively, of the dry material extracted. Traces of an albumin, also, were obtained from extracts from which all the globulin had been precipitated by prolonged and repeated dialysis. The albumin remained in solution during the dialysis and was separated by slightly acidifying and coagulating at 45° C. The yield was from 0.02 to 0.05 per cent. of the bean meal. Analyses showed marked differences in the nitrogen- and sulfur-content of the three proteins. The globulins were still further distinguished from each other by considerable differences in their percentages of the basic amino acids, determined by Van Slyke's method. The  $\beta$ -globulin contained so little cystine that remaining undecomposed after hydrolysis escaped precipitation by phosphotungstic acid and could not be determined by Van Slyke's method.

*The effect of the fat-soluble vitamine content of a feed on the fat-soluble vitamine content of adipose tissue:* J. S. HUGHES. The high fat-soluble vitamine content of beef fat as compared to lard has been explained on the grounds that the ordinary feeds used for steers contain more of this vitamine than the feed usually used for hogs. This explanation implies the assumption that the fat-soluble vitamine content of the tissue can be changed by varying the content of this vitamine in the feed. In order to secure some experimental data on this subject, a number of animals including rabbits, hogs, dogs, hens and ducks were fattened on feed both high and low in the fat-soluble vitamine content. The adipose tissues from these animals were rendered, care being taken not to allow the temperature to go much above the melting point of the fats. The relative fat-soluble vitamine content of the fat from each animal was determined by using it as the only source of this vitamine in an otherwise adequate diet. In no case did the results indicate that the fat-soluble vitamine content of the adipose tissue could be increased by increasing the amount of this vitamine in the feed.

*Further studies upon the local anesthetic and antiseptic action of saligenin and its mercury derivatives and allied compounds:* ARTHUR D. HIRSCHFELDER, MERRILL C. HART, and F. J. KUCERA. Strong solutions of saligenin can be used as a local anesthetic in cystoscopy and dilatation of the male and female urethra. Saligenin is a mild antiseptic and is an analgesic in chronic

arthritides, but we have not found any chemotherapeutic action against trypanosomes or spirochaetes. A di-mercury compound of saligenin has been prepared by refluxing saligenin with 2 mols. of mercuric acetate in dilute alcohol on a water bath for several hours. The sodium salt of this is water soluble and is an excellent antiseptic, about as good as  $\text{HgCl}_2$ , but 1:1000 solutions are non-irritating to mucous membranes, and are being used successfully in the treatment of gonorrheal urethritis. An acetate of this substance has also been prepared.

*The occurrence of diastase in the sweet potato in relation to the production of sweet potato sirup:* H. C. GORE. In the production of sweet potato sirup the potatoes are cooked until soft, crushed finely and mixed with 2 parts of water. Three per cent. of ground barley malt is then added, and the mixture digested at  $60^\circ\text{--}65^\circ\text{C}$ . for from 20 minutes to one hour. During the time nearly all of the starch is changed into maltose and dextrin. Separation of the soluble solids from the insoluble pulp is easily made by use of the rack and cloth type of press or by suction filtration; and the wort is then evaporated into sirup. The yield of sirup is at least 30 per cent. of the weight of potatoes taken. The pulp remaining amounts to 5 per cent. of the weight of potatoes, and may be dried and used for feed. The crude sirup can be used for all cooking purposes for which similar sirups are employed.

*Polynuritis as influenced by the amount of protein and carbohydrate present:* A. D. EMMETT.

*The acid-base balance in animal nutrition. IV. The tolerance of rabbits to acid rations over long periods of time:* A. R. LAMB. Rations complete from the standpoint of nutrition and as nearly as possible of proper physical character for rabbits were so planned from combinations of oats, alfalfa meal, casein and normal sulfuric acid solution, as to furnish a slight excess of acid-forming mineral elements. This excess of acid in the ration was equivalent to about 3 to 5 cc. normal acid solution per rabbit per day. On this ration several rabbits have made normal growth, and one female which has received the ration for eleven months has reproduced successfully, and her progeny have made their entire growth to maturity on the same ration. Most of the acid is excreted normally as phosphates. The ammonia production in the second generation, however, is increased from an average of 0.5 per cent. of the total urinary nitrogen to an average of 2.0 per cent. on the same

ration, a possible adaptation to the abnormal acid character of the ration. This work is being continued.

*Further studies on the effect of a deficiency of fat-soluble vitamine:* V. E. NELSON and ALVIN R. LAMB. Rabbits fed upon a ration of casein, dextrin, salts, wheat embryo and extracted alfalfa, containing practically no fat-soluble vitamine but otherwise complete, invariably develop xerophthalmia. The time of the onset of this symptom varies directly with the age of the rabbit and occurs in young rabbits in four to eight weeks time. A ration consisting of oats, gelatin, salts and extracted alfalfa produced from three to eight weeks before the death of the rabbit. Attempts to induce the disease in the eyes of rats on the same ration by inoculating with the exudate from the eyes of affected rabbits did not succeed. It has not yet been possible to produce the disease in chickens or guinea pigs.

*The hydrogen ion concentration of the contents of the small intestine:* J. F. McCLENDON. Determinations were made on two healthy men about 25 years of age on a mixed diet and the following readings obtained: Subject No. 1,  $\text{pH} = 5.1, 4.5, 4.9, 4.1, 4.2, 6.5$ , average 4.9; subject no. 2,  $\text{pH} = 4.5, 5.2, 4.4, 6.2, 6.4, 5.9$ , average 5.4. The determinations were made by passing a rubber tube, 1.5 mm. bore with 6 gram weight attached through the mouth until it extended 7 feet into the alimentary canal. The tube was allowed to remain in place 5 days and 4 nights while the subjects followed their accustomed occupations. The contents passed out of the tube into a hydrogen electrode vessel. The electrode was made of gold, plated with irridium and was totally immersed in the sample when the readings were taken.

CHARLES L. PARSONS,

(To be continued) Secretary

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## SCIENCE

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